Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 911

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

LIBRARY
RECEIVED
U. S. Department of Agriculture

Washington, D. C. PROFESSIONAL PAPER December 13, 1920

LIFE HISTORY OF THE GRAPE-BERRY MOTH IN NORTHERN OHIO

By

H. G. INGERSON
Scientific Assistant, Deciduous Fruit Insect Investigations

CONTENTS

	Page
Method of Conducting Rearing Work	1
Weather Conditions in 1916, 1917, and 1918	2
Seasonal-history Studies, 1916	2
Seasonal-history Studies, 1917	7
Seasonal-history studies, 1918	24
Miscellaneous Records	32
Summary	37

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 911
Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER December 13, 1920

LIFE HISTORY OF THE GRAPE-BERRY MOTH IN NORTHERN OHIO.[1]

By H. G. Ingerson, *Scientific Assistant, Deciduous Fruit Insect Investigations.*

CONTENTS.

Page.
Method of conducting rearing work.............. 1
Weather conditions in 1916, 1917 and 1918 2
Seasonal-history studies, 1916.................. 2
Seasonal-history studies, 1917.................. 7
Seasonal-history studies, 1918.................. 24
Miscellaneous records.......................... 32
Summary.. 37

METHOD OF CONDUCTING REARING WORK.

The studies reported in this paper on the grape-berry moth (*Polychrosis viteana* Clem.) began in 1916 with the collection of grapes which were infested with early hatching first-brood larvæ. These infested grapes were taken to the open-air insectary and placed in cylindrical wire baskets which held from 1 to 1½ quarts each. These baskets were placed in glass battery jars which had been supplied with about one-half inch of sand in the bottom. This sand absorbed the juice from the infested grapes and maintained a fairly constant humidity in the jars. The jars were closed with cloth covers.

Fresh grape leaves were placed in the battery jars in the space between the wire baskets and the glass surface, and the larvæ pupated in these leaves. The leaves bearing cocoons were removed each day and fresh ones supplied. The cocoons were placed in small jelly glasses until the moths emerged. The moths were removed each day as the records were taken. To secure oviposition records when the moths are confined several different methods have been tried but all without satisfactory results.

---

[1] The data reported in this paper were accumulated during the seasons of 1916, 1917, and 1918. The actual rearing records were secured at Sandusky, Ohio, and the field observations were made in the grape sections about Sandusky, including the Lake Erie islands, in Dover and Avon sections west of Cleveland, and in the Euclid section east of Cleveland.

Control experiments based on these life-history studies were conducted each season and the satisfactory control effected proved the value of such life-history data. The results of the control experiments are published separately as U. S. Department of Agriculture Bulletin 837.

These investigations were conducted in cooperation with the Ohio Agricultural Experiment Station.

During the season of 1916 the writer was assisted by E. R. Selkregg, then field assistant in the U. S. Bureau of Entomology. Mr. Selkregg was in direct charge of the rearing work for 1916. In the seasons of 1917 and 1918 the writer was assisted by Chester I. Bliss, field assistant in the U. S. Bureau of Entomology.

Throughout this work the rearing records have been checked and supplemented by extensive field observations and, except where noted, represent as nearly the actual conditions as it was possible to approximate. Each table presented is to be considered complete in itself and not dependent on any other table. Special methods for the securing of any particular records are given with the records.

WEATHER CONDITIONS IN 1916, 1917, AND 1918.

Seasonal-history data sufficient for accurate timing of spray applications were secured in 1916 and the other data secured were incidental. The weather conditions in the season of 1916 were about normal except for an unusually warm dry autumn. In 1917 the records are more complete, but represent an abnormally late and wet season throughout. The fall was unusually cold and rainy and considerably retarded the development of the second-brood larvæ. In 1918 berry-moth infestation was generally light throughout northern Ohio and difficulty was experienced early in the season in securing sufficient material for rearing records. The season of 1918 opened unseasonably early and remained advanced throughout.

SEASONAL-HISTORY STUDIES, 1916.

These studies began with the collection of early hatching first-brood larvæ in the vineyards. Vineyards known to have been heavily infested in 1915 were searched carefully on June 1, 5, 10, and 14, but not until June 20 was a larva found. At this time only an occasional larva could be found and there was no general infestation of the grape cluster buds. Not until July 5 were larvæ present in the vineyards in any considerable number. Collections of larvæ were made frequently and regularly throughout the season, beginning June 20.

FIRST GENERATION.

TIME OF FIRST-BROOD LARVÆ LEAVING THE FRUIT.

Actual records began with the early hatching larvæ leaving the fruit. Table I shows the dates on which the first-brood larvæ spun their cocoons. The earliest date is seen to be June 28 and the latest August 18, with the greatest number cocooning on July 21. It seems worthy of note that a very large percentage, 81.35 per cent, cocooned within the 12-day period from July 16 to July 27, inclusive.

TABLE I.—*Time of leaving grapes of first-brood larvæ of the grape-berry moth in 1916. Fruit collected at Venice, Put-in-Bay, and Kelley's Island, Ohio.*

Date of leaving fruit.	Number of larvæ.	Date of leaving fruit.	Number of larvæ.
June 28	1	July 26	142
29	1	27	139
July 2	1	28	95
4	3	29	8
5	1	30	28
6	3	31	35
7	5	Aug. 1	27
8	6	3	8
9	4	5	10
10	4	6	73
12	22	7	70
13	63	8	60
14	28	9	59
15	32	10	18
16	163	11	12
17	349	12	11
18	151	13	29
19	316	14	22
20	376	15	12
21	425	16	4
22	346	17	6
23	398	18	14
24	381		
25	164	Total	4,125

LENGTH OF TIME OF FIRST-BROOD INDIVIDUALS IN THE COCOON.

The time of cocooning and length of time in the cocoon for 38 individuals observed are shown in Table II. The maximum time is 19 days, the minimum 9 days, and the average 11.7 days.

TABLE II.—*Time of cocooning and the length of time in cocoon of the first brood of the grape-berry moth at Sandusky, Ohio, in 1916.*

Number of larvæ.	Larvæ left fruit.	Moths emerged.	Days in in cocoon.	Total.	Larvæ collected at—
1	June 28	July 11	13	13	Put-in-Bay, Ohio.
1	...do...	July 12	13	13	Do.
1	July 2	...do...	10	10	Venice, Ohio.
1	July 4	July 14	10	10	Do.
2	...do...	July 15	11	22	Do.
1	July 5	July 16	15	15	Do.
1	July 6	...do...	10	10	Kelley's Island, Ohio.
1	...do...	July 18	13	13	Do.
1	...do...	July 25	19	19	Do.
1	July 7	July 17	10	10	Do.
1	...do...	July 19	12	12	Venice, Ohio.
1	...do...	...do...	12	12	Kelley's Island, Ohio.
6	...do...	July 21	14	84	Do.
5	July 12	...do...	9	45	Do.
1	July 13	July 24	11	11	Do.
10	...do...	...do...	11	110	Venice, Ohio.
2	...do...	July 25	12	24	Do.
1	...do...	July 26	13	13	Do.
38					
		Average	11.7		
		Maximum	19		
		Minimum	9		

TIME OF EMERGENCE OF FIRST-BROOD MOTHS.

The material for securing emergence records of first-brood moths included the larvæ collected beginning June 20 and shown in Tables I and II, and pupæ collected in the field at frequent intervals. It will be seen in Table III and figure 1 that moths began to emerge July 11 and continued until August 31, with the greatest number on August 3. A large part, 63 per cent, of this emergence came within the 11-day period, July 27 to August 6.

TABLE III.—*Time of emergence of moths of the first brood of the grape-berry moth at Sandusky, Ohio, in 1916.*

Date of emergence.	Number of moths.
July 11	1
12	2
13	1
14	1
15	2
16	2
17	1
18	1
19	1
20	3
21	11
22	10
23	7
24	13
25	10
26	43
27	116
28	168
29	164
30	119
31	111
Aug. 1	78
2	118
3	194
4	109
5	190
6	112
Aug. 7	78
8	70
9	25
10	37
11	42
12	20
13	25
14	28
15	37
16	18
17	111
18	67
19	56
20	22
21	18
22	24
23	35
24	13
25	7
26	5
27	6
28	4
29	1
30	2
31	1
Total	2,340

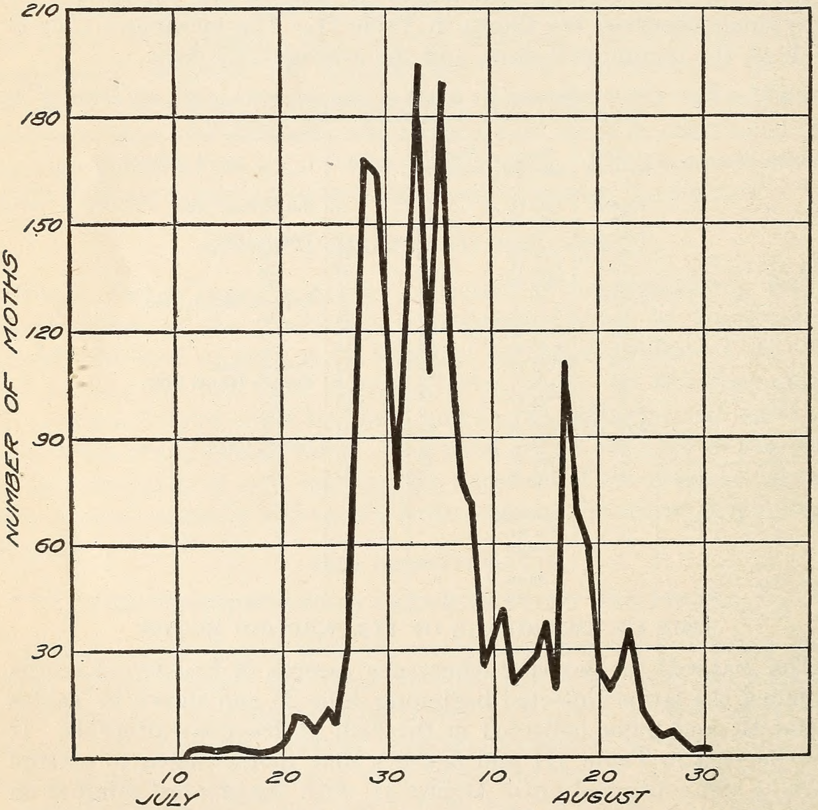

FIG. 1.—Diagram showing time of emergence of first-brood moths of the grape-berry moth (*Polychrosis viteana*) at Sandusky, Ohio, 1916.

OVIPOSITION OF FIRST-BROOD MOTHS.

The oviposition records were secured from some of the moths recorded in Table III. The oviposition of a few of these moths is shown in Table IV. No attempt was made to secure oviposition records throughout the entire oviposition period. From observations made in the vineyards during the season it was found that the heaviest oviposition was in the period from about August 1 to 10. Freshly deposited eggs were found in small numbers in the vineyards as late as August 17, and eggs were being deposited in the insectary as late as September 1.

TABLE IV.—*Oviposition by first-brood moths of the grape-berry moth in rearing jars at Sandusky, Ohio, in 1916.*

No. of jar.	Number of moths.		Date of—			Days—		
	♂	♀	Emergence.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From emergence to last oviposition.
1	2	9	July 24	July 26	July 26	2	1	2
2	14	9	July 27	July 30	July 30	3	1	3
3	12	18	July 28	Aug. 3	Aug. 5	6	2	8
4	(1)	(1)	Aug. 5–6	Aug. 7–8	Aug. 11	2–2	3	6
5	3	14	Aug. 22-23	Aug. 26	Aug. 26	4	1	4
Average						3.4	1.6	4.6
Maximum						6	3	8
Minimum						2	1	2

(1) No record.

SECOND GENERATION.

TABLE V.—*Incubation period of second-brood eggs of the grape-berry moth at Sandusky, Ohio, 1916.*

Number of observation.	Date of oviposition.	Date of hatching.	Days of incubation.	Number of eggs.
1	Aug. 3	Aug. 8	5	No record.
2	Aug. 7–8	Aug. 11	4	Do.
3	Aug. 9–10	Aug. 13	4	52.
4	Aug. 11	Aug. 16	5	39.
5	Aug. 27–28	Sept. 3	7	No record.
6	Aug. 30	Sept. 5	6	Do.
7	Sept. 1	Sept. 6	5	Do.

Average length of incubation period, 5.1 days.
Maximum length of incubation period, 7 days.
Minimum length of incubation period, 4 days.

The incubation period of second-brood eggs as shown in Table V averaged 5.1 days with 7 days as the maximum time and 4 days as the minimum. It may be assumed then that the earliest second-brood larvæ began feeding about July 21, 10 days after the emergence of moths on July 11. The hatching, however, was light until about August 5, when larvæ began to be present in the vineyards in large numbers. Though some larvæ hatched in the insectary as late as September 6, in the vineyards most of the larvæ had hatched by August 25.

FEEDING PERIOD OF SECOND-BROOD LARVÆ IN REARING CAGES.

Records from the date of hatching to the date of cocooning were secured from 51 individuals as shown in Table VI.

TABLE VI.—*Feeding period of second-brood larvæ of the grape-berry moth in rearing cages, Sandusky, Ohio, 1916.*

Date of hatching.	Date of cocooning.	Number of cocoons.	Feeding period.	Total.
			Days.	*Days.*
Aug. 11	Aug. 31	2	20	40
Do	Sept. 1	5	21	105
Do	Sept. 6	4	26	104
Do	Sept. 7	1	27	27
Aug. 13	Aug. 31	1	18	18
Do	Sept. 1	2	21	42
Do	Sept. 2	1	22	22
Do	Sept. 4	4	24	96
Do	Sept. 7	4	27	108
Do	Sept. 9	2	29	58
Do	Sept. 10	1	30	30
Aug. 16	Sept. 1	3	16	48
Do	Sept. 4	5	19	95
Do	Sept. 9	3	24	72
Do	Sept. 10	3	25	75
Do	Sept. 11	3	26	78
Do	Sept. 12	3	27	81
Do	Sept. 14	1	29	29
Sept. 5	Oct. 11	1	36	36
Sept. 6	Oct. 9	1	33	33
Do	Oct. 12	1	36	36
Total		51		1,233
Average			24.18	
Maximum			36	
Minimum			16	

The average length of the feeding period for the 51 larvæ was 24.18 days, a much shorter period than has previously been recorded as the average for the second brood. This shortening was due no doubt to the unseasonably warm weather that prevailed during August, September, and early October of 1916. This figure should not be taken as representing the usual condition, but is presented here to show the influence of a warm fall on the maturing of the larvæ. The maximum length of the feeding period was 36 days and the minimum 16.

LENGTH OF THE PREPUPAL PERIOD.

The length of time between the spinning of the cocoon and pupation was recorded for 13 individuals as shown in Table VII.

TABLE VII.—*Length of the prepupal period of 13 individuals of the second brood of the grape-berry moth, Sandusky, Ohio, 1916.*

Date of spinning cocoon.	Number of cocoons.	Date of pupation.	Number of days in prepupal stage.	Total number of days.
Aug. 31	1	Sept. 3	3	3
Do	1	Sept. 4	4	4
Do	1	...do....	4	4
Sept. 1	2	...do....	3	6
Do	5	Sept. 5	4	20
Do	2	Sept. 6	5	10
Do	1	Sept. 8	7	7
Total	13			54

Average length of prepupal period, 4.15 days.
Maximum length of prepupal period, 7 days.
Minimum length of prepupal period, 3 days.

The average length of the prepupal period was 4.15 days, the maximum 7 days, and the minimum 3 days.

TIME OF COCOONING OF THE SECOND-BROOD LARVÆ.

In an effort to determine the percentage of worms normally removed from the vineyards with the harvested grape crop the following records were secured:

TABLE VIII.—*Time of cocooning of the second brood of the grape-berry moth at Sandusky, Ohio, in 1916.*

Date of cocooning.	Number of cocoons.	Date of cocooning.	Number of cocoons.
Aug. 22	1	Sept. 27	244
Aug. 23	1	Sept. 28	109
Aug. 24	6	Sept. 29	46
Aug. 25	3	Sept. 30	18
Aug. 28	44	Oct. 1	33
Aug. 29	5	Oct. 2	40
Aug. 30	39	Oct. 3	64
Aug. 31	43	Oct. 4	87
Sept. 1	157	Oct. 5	119
Sept. 2	121	Oct. 6	64
Sept. 4	350	Oct. 7	51
Sept. 5	163	Oct. 8	55
Sept. 6	120	Oct. 9	16
Sept. 7	335	Oct. 10	10
Sept. 8	340	Oct. 11	15
Sept. 9	254	Oct. 12	9
Sept. 10	153	Oct. 13	15
Sept. 11	343	Oct. 14	14
Sept. 12	309	Oct. 15	9
Sept. 13	402	Oct. 17	16
Sept. 14	233	Oct. 19	8
Sept. 15	197	Oct. 21	6
Sept. 16	94	Oct. 23	5
Sept. 17	145	Oct. 25	4
Sept. 18	114	Oct. 27	6
Sept. 19	101	Oct. 29	6
Sept. 20	142	Nov. 1	6
Sept. 21	251	Nov. 3	2
Sept. 22	171	Nov. 5	4
Sept. 23	94	Nov. 7	4
Sept. 24	68		
Sept. 25	126	Total	6,138
Sept. 26	128		

Larvæ began to leave the grapes as early as August 22 and continued to leave as late as November 7. The table further shows that 77 per cent of the larvæ left the fruit previous to September 25, the date of the beginning of the Concord harvest, and that 90 per cent had left the grapes previous to the beginning of the Catawba harvest on October 3. From these data it would seem that little control is effected by the removal of the worms with the crop.

SEASONAL-HISTORY STUDIES, 1917.

The 1917 rearing records begin with the emergence of spring-brood moths from overwintered pupæ. These pupæ were kept under a leaf blanket in the insectary yard, a condition similar to that in a protected part of the vineyard. At the time when "plowing away" from the vines began in the Sandusky section May 14, the cocoons were moved from the wintering place to the insectary, placed in rearing jars, and records of moth emergence taken as shown in Table IX.

TABLE IX.—*Time of emergence and sex of moths of the spring brood of the grape-berry moth, Sandusky, Ohio, 1917.*

Date of emergence.	Number of moths.				Mean daily temperature.
	♂	♀	[1] ⚥	Total.	
June 9	......	2	......	2	62
June 10	......	1	......	1	62
June 12	2	1	......	3	70
June 13	2	1	......	3	72
June 15	......	1	......	1	51
June 16	1	1	......	2	54
June 17	......	3	......	3	60
June 18	5	9	3	17	69
June 19	10	16	2	28	73
June 20	1	1	......	2	66
June 21	10	6	3	19	68
June 22	34	46	1	81	68
June 23	3	6	......	9	72
June 24	13	51	......	64	62
June 25	18	82	2	102	63
June 26	17	56	3	76	78
June 27	7	31	......	38	69
June 28	32	90	2	124	70
June 29	13	39	1	53	68
June 30	17	79	2	98	69
July 1	15	36	3	54	76
July 2	10	37	2	49	69
July 3	6	27	......	33	64
July 4	1	31	1	33	63
July 5	5	32	1	38	64
July 6	6	35	......	41	66
July 7	5	46	......	51	74
July 8	4	26	4	34	71
July 9	8	38	......	46	76
July 10	5	35	......	40	65
July 11	2	6	......	8	63
July 12	10	37	......	47	66
July 13	1	6	......	7	64
July 14	4	20	......	24	70
July 15	8	22	1	31	72
July 16	7	20	1	28	74
July 17	5	27	......	32	72
July 18	1	12	......	13	70
July 19	4	28	2	34	71
July 20	3	4	3	10	76
July 21	5	14	2	21	76
July 22	2	11	......	13	76
July 23	1	7	......	8	78
July 24	1	8	......	9	80
July 25	......	7	1	8	78
July 26	......	2	1	3	80
July 27	......	1	......	1	76
July 28	......	9	1	10	72
July 29	......	2	......	2	86
July 30	......	2	1	3	87
July 31	......	2	......	2	88
Aug. 1	1	1	......	2	88
Aug. 2	......	1	......	1	74
Aug. 5	......	1	......	1	80
Aug. 10	......	1	......	1	66
Total	305	1,116	43	1,464	......

[1] ⚥ Denotes specimens the sex of which was undetermined.

SPRING BROOD.

EMERGENCE OF SPRING-BROOD MOTHS.

In addition to the time of emergence and number of moths emerging each day, the sex of the moths was determined and recorded.

Moths began to emerge June 9, but did not emerge in any considerable numbers until June 22. (Fig. 2.) From this date emergence was heavy for about 10 days and then fell off gradually until the end of the emergence period on August 10.

RELATION OF EMERGENCE OF SPRING MOTHS TO GRAPE BLOOM.

The relation between the time of emergence and the blossoming period of grapes is of interest in substantiating earlier records.

TABLE X.—*Relation between the time of emergence of the spring brood of grape-berry moths and the period of grape bloom, Sandusky, Ohio, 1917.*

Period.	Dates inclusive.	Male moths.		Female moths.		Sex undetermined moths.		Total.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Before grape bloom	June 9–20	21	6.88	36	3.22	5	11.63	62	4.23
During grape bloom	June 21–July 1	179	58.68	522	46.77	17.	39.53	718	49.04
Ten days after bloom	July 2–11	52	17.05	313	28.04	8	18.60	373	25.47
Remainder of season	July 12–Aug. 10	53	17.38	245	21.97	13	30.24	311	21.25
Total		305	......	1,116	......	43	......	1,464	......

The blooming period of grapes from June 21 to July 1 begins with the bloom of the Ives variety, one of the varieties grown commercially in the northern Ohio sections, and ends with the falling of bloom from the Catawba variety, also a commercial variety of importance in the sections studied. It is seen that less than 5 per cent of the total emergence occurred before the beginning of bloom, 50 per cent in the 10-day period during bloom, 25 per cent in the next 10-day period, and 21 per cent during the remainder of the season.

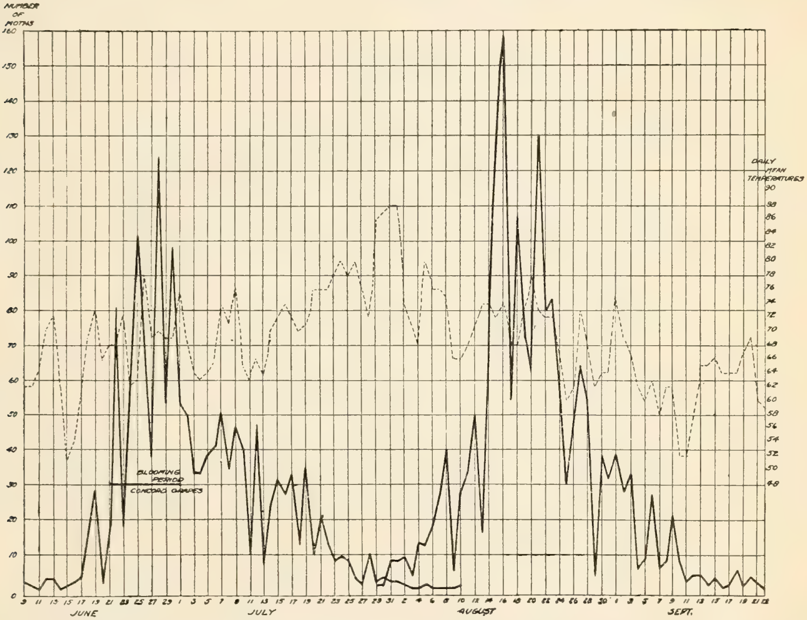

FIG. 2.—Diagram showing the time of emergence of spring-brood and first-brood moths of the grape-berry moth at Sandusky, Ohio, 1917.

A rather close correlation is evident between the rate of emergence and the daily mean temperatures.

PROPORTION OF SEXES OF SPRING-BROOD MOTHS.

TABLE XI.—*Proportion of sexes of spring moths of the grape-berry moth, Sandusky, Ohio, 1917.*

Sex of moths.	Number of moths.	Per cent of sexes.
Male	305	21.46
Female	1,116	78.54
Undetermined	43	....
Total	1,464	100.00

The high percentage of female moths, as shown in Table XI, seems to account for the frequent heavy infestation by second-brood larvæ after a comparatively light first-brood infestation.

PERCENTAGE OF EMERGENCE OF SPRING MOTHS.

TABLE XII.—*Percentage of emergence of spring moths of the grape-berry moth from hibernation under a leaf blanket in insectary yard, Sandusky, Ohio, 1917.*

Lot No.	Source of material.	Number of cocoons.	Number of moths emerged.	Emergence.
				Per cent.
1	Collected as larvæ at Venice, Ohio, 1916	2,082	780	37.46
2	Collected as larvæ at Put in Bay, Ohio, 1916	1,493	236	15.80
3	Collected as larvæ at Kelleys Island, Ohio, 1916	2,371	231	9.74
4	Collected as larvæ at Venice, Ohio, 1916	82	12	14.63
	Total	6,028	1,259	
	Average			20.88

No explanation is offered for the variations in percentages of emergence from material collected at the different places. The material was all collected as larvæ in the infested grapes at similar times and kept under identical conditions after collection. That but 20 per cent of the cocoons formed withstood the winter under a light leaf blanket indicates that the natural mortality is considerable.

TIME OF DAY OF MOTH EMERGENCE.

Records were taken as opportunity offered on the time of day of moth emergence. These records were in the period July 8 to July 17 or about in the middle of the emergence period. They indicated in a general way that emergence began in the morning as soon as the heat of the day was felt and that practically all emergence took place between 6.30 a. m. and noon.

OVIPOSITION BY THE SPRING BROOD OF MOTHS.

A few records of oviposition were secured and are shown in Table XIII. These meager records serve only as an indication of the actual conditions prevailing.

TABLE XIII.—*Oviposition of spring moths of the grape-berry moth in rearing cages, Sandusky, Ohio, 1917.*

Observation No.	Number of moths.		Date of—			Days—		
	♂	♀	Emergence of moths.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From emergence to last oviposition.
1	2	4	June 18	June 21	June 24	3	4	6
2	10	10	June 27	July 2	July 2	5	1	5
3	4	10	July 18	July 21	July 23	3	3	5
4	4	12	July 20	July 22	July 26	2	5	6
5	2	11	July 23	July 24	July 28	1	5	5
Average						2.8	3.6	5.4

PLACE OF OVIPOSITION ON THE VINE.

It was found that a vine of the Clinton variety set in a row of Concords was heavily oviposited upon before the Concord berries were formed. For use in the spacing of spray nozzles for the set-nozzle method of spraying, the place of oviposition on the vine seemed important. The place of oviposition on this one vine by the spring brood of moths was recorded and the data are presented in Table XIV. The vine was trained according to the fan system of grape training which is generally used for all varieties in the northern Ohio sections. In the fan system the vine growth which is trained to an upright trellis is annually renewed to within a short distance of the ground. The vines are cut back usually to from 2 to 4 canes and as many spurs each year; the canes are spread out and tied to the trellis obliquely, giving the shape of a fan.

TABLE XIV.—*Place of oviposition on vine by spring moths of the grape-berry moth under natural conditions in vineyard, Venice, Ohio, 1917.*

Place on vine.	Distances.	Number of clusters.	Number grapes bearing eggs.	Number eggs.	Number eggs per cluster.	Percentage of— Deposition in this space.	Percentage of— Clusters in this space.
	Inches.						
Between ground and first wire	21	15	82	107	7	17	33.3
Between first and second wire	21–33	23	260	333	15	53	51.1
Between second and third wire	33–49	7	124	190	29	30	15.5
Total		45	466	630		100	100.0
Average					14.0		

The figures in Table XIV agree with the usual observation that the clusters near the ground are less heavily infested than those higher up on the vines. Thirty per cent of the deposition occurred between the middle wire and top wire, whereas but 15 per cent of the clusters were in that space. These figures likewise agree with field observations in that the heavy infestation is generally where the clusters are well covered with foliage, a condition which prevails near the top of the trellis.

In Table XV are presented records of the length of the incubation period of eggs of the first brood. The average number of days required for incubation was 4.39, the maximum 8 days, and the minimum 3 days. These figures include both insectary material and eggs collected in the vineyard when the date of deposition was known. In obtaining the eggs from the vineyards all eggs were removed from the vines each day.

FIRST GENERATION.

INCUBATION PERIOD OF FIRST-BROOD EGGS.

TABLE XV.—*Incubation period of first-brood eggs of the grape-berry moth, Sandusky, Ohio, 1917.*

Date of oviposition.	Date of hatching.	Number of larvæ.	Incubation period (in days).
June 21	June 28	4	7
30	July 4	28	4
30	July 5	18	5
30	July 6	8	6
30	July 8	1	8
July 1	July 5	24	4
1	July 6	6	5
1	July 7	2	6
1	July 6	18	4
1	July 7	2	5
21	July 24	1	3
22	July 25	2	3
23	July 26	1	3
23	July 28	1	5
24	July 28	2	4
24	July 30	4	6
26	July 29	2	3
26	July 30	3	4
26	July 30	27	4
27	July 31	11	4
Total		165	

Average length of incubation period, 4.39 days.
Maximum length of incubation period, 8 days.
Minimum length of incubation period, 3 days.

LENGTH OF FEEDING PERIOD OF FIRST-BROOD LARVÆ.

Records from the date of hatching until date of leaving fruit were secured on 70 larvæ in the insectary.

TABLE XVI.—*Length of feeding period of 70 first-brood larvæ of the grape-berry moth in grapes in rearing jars in the insectary, Sandusky, Ohio, 1917.*

Number of larvæ.	Larvæ hatched.	Larvæ left fruit.	Feeding period.	Number of larvæ.	Larvæ hatched.	Larvæ left fruit.	Feeding period.
			Days.				*Days.*
2	July 3	July 21	18	2	July 5	July 25	20
2	do	July 25	22	1		July 28	23
1	do	July 26	23	2	July 5	July 29	24
1	do	July 29	26	1	do	July 31	26
1	do	July 30	27	1	do	Aug. 1	27
1	do	Aug. 5	33	1	do	Aug. 2	28
2	July 4	July 19	15	2	do	Aug. 6	32
3	do	July 21	17	3	July 6	July 22	16
2	do	July 22	18	6	do	July 23	17
6	do	July 23	19	1	do	July 26	20
2	do	July 24	20	1	do	July 27	21
1	do	July 27	23	1	do	July 30	24
1	do	July 28	24	1	do	July 31	25
2	do	July 29	25	1	do	Aug. 1	26
1	do	Aug. 5	32	1	do	Aug. 2	27
1	July 5	July 19	14	1	do	Aug. 12	37
1	do	July 20	15	1	July 7	July 21	14
3	do	July 21	16	1		July 25	18
4	do	July 22	17	—			
3	do	July 23	18	70			
2	do	July 24	19				

Average days, 20.62.
Maximum days, 37.
Minimum days, 14.

The average length of the feeding period is seen to be 20.62 days, the maximum 37 days, and the minimum 14 days. The records extended throughout the regular hatching period, and therefore reflect vineyard conditions closely.

LENGTH OF THE PREPUPAL PERIOD OF FIRST-BROOD INDIVIDUALS.

In Table XVII are given the dates of cocooning and the length of the period from the time of spinning the cocoon until pupation for individuals some of which were supplied with sprayed foliage and others with unsprayed foliage.

Table XVII.—*Time of cocooning and length of prepupal period of 231 individuals of the first brood of the grape-berry moth, Sandusky, Ohio, 1917.*

	Number of cocoons.
Foliage unsprayed:	
Dates of cocooning—	
August 3	50
August 4	50
August 5	50
August 7	39
August 8	34
Foliage sprayed:	
August 7	40
August 8	24

Dates of pupation.	Number of pupæ by days.						
Aug. 4	17	......	......	......	......	......	......
5	26	7	......	......	......	......	......
6	3	28	21	......	......	......	......
7	......	7	18	......	......	......	......
8	......	......	1	21	......	2	......
9	......	......	......	14	1	11	......
10	......	......	......	1	18	7	2
11	......	......	......	......	11	......	5
12	......	......	......	......	......	3	6
13	......	......	......	......	......	......	1
Total number of pupæ	46	42	40	36	30	23	14
Dead in cocoons	4	8	10	3	4	17	10

Table XVIII.—*Summary of Table XVII. Length of prepupal period of 231 individuals of the first brood of the grape-berry moth, Sandusky, Ohio, 1917.*

Number individuals.			Prepupal period.
Cocooned on unsprayed foliage.		Cocooned on sprayed foliage.	
			Days.
67		2	1
104		13	2
23		12	3
....		6	4
....		4	5
194		37	....
Average	1.77	2.9	....
Maximum	3	5	....
Minimum	1	1	....

The data from Table XVII are summarized in Table XVIII. The average length of the prepupal period was 1.77 days, the maximum period 3 days, and the minimum 1 day, where unsprayed foliage was supplied. Where the cocoons were formed on sprayed foliage the average prepupal period was 2.9 days, the maximum 5 days, and the minimum 1 day. The spray material apparently had a repellent action, for in another experiment where both sprayed and unsprayed foliage were equally accessible to larvæ there were 226, or 63 per cent, of the total number of cocoons formed on unsprayed leaves and but 135, or 37 per cent, formed on sprayed leaves. Considerable mortality can be attributed to cocooning on sprayed leaves, since 194 pupæ were formed in 223 cocoons on unsprayed leaves, a mortality of 13 per cent as compared with the individuals that cocooned on sprayed leaves, where but 37 pupæ were formed in 64 cocoons, showing a mortality of 42 per cent.

TIME OF COCOONING OF FIRST-BROOD LARVÆ.

TABLE XIX.—*Time of cocooning of 2,447 larvæ of the first brood of the grape-berry moth, Sandusky, Ohio, 1917.*

Date of cocooning.	Number of cocoons.	Mean daily temperature.	Date of cocooning.	Number of cocoons.	Mean daily temperature.
		°*F.*			°*F.*
July 19	3	71	Aug. 14	51	74
July 20	2	76	Aug. 15	28	72
July 21	9	76	Aug. 16	36	74
July 22	9	76	Aug. 17	31	68
July 23	18	78	Aug. 18	58	68
July 24	10	80	Aug. 19	35	73
July 25	31	78	Aug. 20	58	78
July 26	44	80	Aug. 21	33	73
July 27	55	76	Aug. 22	33	72
July 28	73	72	Aug. 23	30	72
July 29	54	86	Aug. 24	21	66
July 30	128	87	Aug. 25	8	60
July 31	170	88	Aug. 26	9	62
Aug. 1	129	88	Aug. 27	17	73
Aug. 2	142	74	Aug. 28	5	68
Aug. 3	230	71	Aug. 29	5	62
Aug. 4	117	68	Aug. 30	1	64
Aug. 5	112	80	Aug. 31	6	64
Aug. 6	131	76	Sept. 1	4	75
Aug. 7	158	76	Sept. 2	8	69
Aug. 8	111	75	Sept. 3	1	67
Aug. 9	26	66	Sept. 6	1	66
Aug. 10	64	66	Sept. 8	1	62
Aug. 11	37	68			
Aug. 12	62	71	Total	2,447	
Aug. 13	45	74			

In Table XIX are given the complete records of cocooning for the first-brood larvæ. Cocooning began on July 19 and continued until September 8 with a distinctly high period from July 30 until August 8. The correlation with temperature is of interest, showing that as the mean temperature dropped below 70° F. there was a drop in the rate of cocooning.

LENGTH OF PUPAL STAGE OF FIRST-BROOD PUPÆ.

TABLE XX.—*Time of cocooning and length of pupal stage of 90 individuals of the first-brood pupæ of the grape-berry moth, Sandusky, Ohio, 1917.*

UNSPRAYED FOLIAGE FOR COCOONING.

Number of larvæ.				Date of pupation.	Date of moth emergence.	Days in pupal stage.		
♂	♀	⚥	Total.			♂	♀	⚥
....	3	....	3	Aug. 4	Aug. 16	0	12	....
....	4	....	4	do	Aug. 18	....	14	....
2	7	....	9	Aug. 5	do	13	13	....
3	8	....	11	do	Aug. 19	14	14	....
1	2	....	3	Aug. 7	Aug. 21	14	14	....
....	1	....	1	do	Aug. 22	....	15	....
....	1	....	1	do	Aug. 23	....	16	....
....	2	1	3	Aug. 8	Aug. 20	....	12	12
1	8	....	9	do	Aug. 21	13	13	....
....	1	....	1	do	Aug. 22	....	14	....
....	4	1	5	Aug. 9	Aug. 21	....	12	12
1	2	....	3	do	Aug. 22	13	13	....
....	5	....	5	Aug. 10	do	....	12	....
2	5	....	7	do	Aug. 23	13	13	....
....	2	....	2	do	Aug. 24	....	14	....
....	1	....	1	Aug. 11	Aug. 22	....	11	....
....	2	....	2	do	Aug. 23	....	12	....
....	1	....	1	do	Aug. 27	....	16	....
10	59	2	71	Average	....	13.4	13.11	12

SPRAYED FOLIAGE FOR COCOONING.

Number of larvæ.				Date of pupation.	Date of moth emergence.	Days in pupal stage.		
♂	♀	⚥	Total.			♂	♀	⚥
....	1	....	1	Aug. 8	Aug. 21	....	13	....
....	1	....	1	do	Aug. 22	....	14	....
....	3	....	3	Aug. 9	Aug. 23	....	14	....
....	2	....	2	do	Aug. 24	....	15	....
....	1	....	1	do	Aug. 25	....	16	....
....	1	1	2	Aug. 10	Aug. 23	....	13	13
....	1	....	1	do	Aug. 24	....	14	....
....	1	....	1	Aug. 11	Aug. 23	....	12	....
1	....	....	1	do	Aug. 27	16	....	....
....	2	....	2	Aug. 12	Aug. 26	....	14	....
....	1	....	1	do	Aug. 27	....	15	....
1	1	....	2	do	Aug. 28	16	16	....
....	1	....	1	do	Aug. 30	....	18	....
2	16	1	19	Average	....	16	15	13

In Table XX the length of the pupal stage of 90 individuals is given. The average length of the stage was 13.4 days for males and 13.11 for females, all on unsprayed foliage. On sprayed foliage the average length of the period was 16 days for males and 15 for females.

LENGTH OF TIME SPENT IN THE COCOON BY FIRST-BROOD INDIVIDUALS.

The average length of time in the cocoon on unsprayed foliage is shown in Table XXI to be 15.52 days for males with 32 days as the maximum period and 9 days as the minimum. For females on unsprayed foliage 14.62 days was the average period, 32 days the maximum, and 6 the minimum. On sprayed foliage males were in the cocoons 16.82 days as the average with 20 days as the maximum and 16 days the minimum period. Females were in the cocoons an average of 17.06 days with 27 days as the maximum and 13 days the minimum.

TABLE XXI.—*Length of time in cocoon of 1.318 individuals of the first brood of the grape-berry moth, Sandusky, Ohio, 1917.*

Sex of moths.	Number of moths.	Number of days in cocoon.		
		Average.	Maximum.	Minimum.
Male	226	15.52	32	9
Female	1,003	14.62	32	6
Undetermined	25	14.32	20	9
Total	1,254	14.78	32	6
Cocooned on sprayed foliage:				
Male	11	16.82	20	16
Female	53	17.06	27	13
Total	64	17.01	27	13

TIME OF EMERGENCE OF FIRST-BROOD MOTHS.

TABLE XXII.—*Time of emergence and sex of the first-brood moths of the grape-berry moth, Sandusky, Ohio, 1917.*

Date of emergence.	Number of moths.				Date of emergence.	Number of moths.			
	♂	♀	☿	Total.		♂	♀	☿	Total.
July 29	0	1	0	1	Aug. 26	8	42	0	50
30	0	1	0	1	27	12	50	3	65
31	1	6	1	8	28	7	45	1	53
Aug. 1	2	5	1	8	29	0	3	0	3
2	4	4	1	9	30	14	23	0	37
3	0	3	1	4	31	4	27	1	32
4	1	12	0	13	Sept. 1	5	31	1	37
5	4	8	0	12	2	2	27	1	30
6	1	16	0	17	3	10	23	0	33
7	7	20	0	27	4	0	6	0	6
8	4	33	3	40	5	5	3	0	8
9	0	5	0	5	6	4	20	2	26
10	2	25	1	28	7	1	5	0	6
11	7	26	0	33	8	1	8	0	9
12	7	43	0	50	9	4	14	0	18
13	2	14	0	16	10	1	7	0	8
14	20	66	0	86	11	0	2	0	2
15	19	110	1	130	12	1	3	0	4
16	24	128	8	160	13	2	2	0	4
17	10	41	3	54	14	0	1	0	1
18	21	85	0	106	15	1	2	0	3
19	19	49	4	72	17	0	1	0	1
20	6	55	1	62	18	1	4	0	5
21	23	105	2	130	19	0	1	0	1
22	19	61	0	80	20	1	2	0	3
23	13	66	4	83	21	2	0	0	2
24	9	44	1	54	22	0	1	0	1
25	5	27	0	32					
					Total	316	1,412	41	1,769

First-brood moths began to emerge on July 29 and emergence continued until September 22. It will be seen in figure 2 that the emergence was high for the entire period of August 12 to 28, varying with the mean daily temperature. It is also shown that the emergence of the first-brood moths began before the spring brood emergence ended. This means that moths were emerging practically from grape bloom until grape harvest; the majority of all emergence, however, occurred in two well-defined periods, as shown graphically in figure 2.

PROPORTION OF SEXES OF FIRST-BROOD MOTHS.

TABLE XXIII.—*Proportion of sexes of first-brood moths of the grape-berry moth, Sandusky, Ohio, 1917.*

Sex of moths.	Number of moths.	Percentage of sexes.
Male	316	18.28
Female	1,412	81.72
Undetermined	41	....
Total	1,769	100.00

The high percentage of female moths helps further to explain the occurrence of a large second brood of larvæ.

LIFE CYCLE OF THE FIRST GENERATION.

TABLE XXIV.—*Life cycle of the first generation of the grape-berry moth as determined from observations on the separate stages; summaries from the previous tables, Sandusky, Ohio, 1917.*

Summary from Table No.—	Stage.	Number of individuals.	Days of duration of stage.		
			Average.	Maximum.	Minimum.
XV	Egg stage	165	4.39	8	3
XVI	Length of feeding period of larvæ	70	20.62	37	14
XXI XXI	Making of cocoon and pupal stage	1,254	14.78	32	6
	Total life cycle	....	39.79	77	23

The life cycle as here presented is seen to average 39.79 days with 77 days as the total of the maximums and 23 days as the total of the minimums. To the average of 39.79 should be added the period between moth emergence and oviposition, which is usually 3 days, thus making the total life cycle 42.79 days.

SECOND GENERATION.

INCUBATION PERIOD OF SECOND-BROOD EGGS.

One record only was secured concerning the incubation period of second-brood eggs, and that late in the season when the temperature was comparatively low. Twenty-two eggs were deposited on September 1, the black spot was evident on September 9, and the eggs hatched September 11, 10 days after oviposition.

TIME OF COCOONING OF SECOND-BROOD LARVÆ.

The dates on which larvæ were leaving the grapes and spinning cocoons are shown in detail in Table XXV.

TABLE XXV.—*Time of cocooning and number of cocoons of the second brood of the grape-berry moth, Sandusky, Ohio, 1917.*

Date of cocooning.	Dates of collection of larvæ.						
	August—			September—			
	30	30	30	2	3	3	6
Sept. 7		1	1	1			
8							
9		1		1		1	
10						1	
11			1				
12							
13		2	1	2			
14		1	2	1		1	
15	1	1	1	1	1	2	
16	1	1	2	2			
17		2	2	1			
18		1	1	1		2	
19	1	1	3	1	1		
20	1	2	9	2	1	7	
21	2	1	5	3	1	1	1
22	5	2	9	3	0	2	1
23	0		5	2	3	3	1
24	5	2	10	8	8	10	7
25	5	4	8	6	8	3	4
26	5	1	5	1	2	9	3
27	8	3	6	6	8	7	5
28	5	9	5	7	4	11	10
29	7	2	3	4	6	3	7
30	5	2	5	12	2	1	6
Oct. 1	1	4	2	2	1	2	4
2	8	2	4	3	6	2	4
3	3	4	7	10	9	4	8
4	2	1	5	6	4	5	6
5	6	10	6	3		2	5
6							
7	4	2	2	3	2		1
8		1		1	4	2	7
9	1			2		2	1
10		2		2	1		1
11	2	2			5	2	2
12					2	4	1
13				1			
15	4	7	3	9	10	6	3
16	7	6	5	5	10	3	1
17		3	1	3	1	2	3
18		5	3	2	8	4	4
19	4	3	6	5	13	5	14
20							
21					1		
22					1		
23							
24							
25							
26							
27							
28					1		
29							
30		4				2	
31							
Nov. 5							
10							
Jar discontinued	Oct. 22	Nov. 10	Nov. 10	Nov. 21	Nov. 10	Nov. 10	Nov. 10

TABLE XXV.—*Time of cocooning and number of cocoons of the second brood of the grape-berry moth, Sandusky, Ohio, 1917*—Continued.

Date of cocooning.	Dates of collection of larvæ.						
	September—						
	6	6	9	9	9	12	12
Sept. 7		3					
8							
9							
10							
11							
12							
13		1			1		
14	1						
15	1			1	1		
16	1	1					
17				3		1	
18						1	
19	1	1				2	2
20	1						1
21		1			3	3	1
22	1	2		2	4	3	
23	2	1				2	
24	5	2		4	3		1
25	4	1	1		4	7	
26	1	2	2	2	1	4	
27	4	3	3	3	14	7	5
28	4	5		2	11	8	4
29	4	2	1	3	14	2	1
30	4	4	3	2	4	5	2
Oct. 1	1	2		3	1	2	
2	3	1	4	1	1	1	1
3	1		6	2	4	3	4
4	7	5	1	4	4	2	4
5	8	3	3	9		1	
6							
7	12	5	2	2	4	4	1
8	4	2	1		7	2	1
9	1		1	1	2		
10	1					1	
11					3	1	2
12	1	4		2	4		3
13		1					
15	15	8	1	4	20	3	12
16	12	6	3	2	8	1	8
17	1	2	3	1	6		2
18	5	5		6	6	4	10
19	9	10		4	19		11
20							
21		1					
22	2						1
23	4			1			
24				1			1
25		3					
26					2		
27							
28	3			1	3	1	1
29					2		
30	4		2	2			
31							
Nov. 5							
10					13		
Jar discontinued	Nov. 21	Oct. 31	Nov. 21	Nov. 21	Nov. 10	Nov. 10	Nov. 10

TABLE XXV.—*Time of cocooning and number of cocoons of the second brood of the grape-berry moth, Sandusky, Ohio, 1917*—Continued.

Date of cocooning.	Dates of collection of larvæ.						
	September—						
	12	14	15	15	15	18	18
Sept. 7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18				1			
19					1		
20	3			2			
21	2				2		
22	2				1		
23			1				
24	4		3	4	2		
25	2	1	3	8			1
26	1		3	2	2		
27	12		4	7	8		1
28	4	1	6	11	10		1
29	7	1	2	9	5	1	
30	5		4	4	5		1
Oct. 1	1	1	4	5	5		
2			1	2			3
3	7	4	11	13	16	1	3
4	8	3	3	8		1	1
5		3	9	14	6	2	
6							
7	7		3	9	5		
8	2		3	3	2	1	2
9					2		
10			1	2	2		
11	1		1	1	3		
12	2		1	6	2	1	
15	15		9	17	4		2
16	10		8	11	5	1	2
17	3		3	3	3		
18	12		2	10	11	4	
19	14						
20			12	27	11		
21				1	1		
22					1		
23	1	2					
24					2		
25				1			
26							
27							
28	2			9	6		
29	4			4			
30			1	3	5	2	2
31							
Nov. 5							
10							
Jar discontinued	Nov. 21	Nov. 22	Nov. 21	Nov. 26	Nov. 21	Nov. 21	Nov. 21

Table XXV.—*Time of cocooning and number of cocoons of the second brood of the grape-berry moth, Sandusky, Ohio, 1917*—Continued.

Date of cocooning.	Dates of collection of larvæ.						
	September—						
	18	22	22	22	29	29	29
Sept. 7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25		2					
26	1		1				
27	1	2	1	1			
28		5					
29	1	3					
30	1	3					
Oct. 1		1					
2	1		1		1		
3		3		2	3	6	
4	1	2		6	1		3
5		2	2	2		1	2
6							
7		3		1		6	4
8		7		2	2	2	3
9		3					
10		1					
11					1		
12				1			
15	1	6	3	2	2	1	1
16	1	6	1	1	1	10	9
17		1	2	1		3	5
18	1	5	5	6	3		
19							
20	3	4	7	6	4	13	7
21	1						
22				1			
23							
24						1	
25				1	1		
26							
27							
28			2				
29							
30	1			1		1	
31							
Nov. 5							
10							
Jar discontinued	Nov. 9	Nov. 9	Nov. 9	Nov. 9	Nov. 6	Nov. 9	Nov. 9

TABLE XXV.—*Time of cocooning and number of cocoons of the second brood of the grape-berry moth, Sandusky, Ohio, 1917*—Continued.

Date of cocooning.	Dates of collection of larvæ.						Total cocoons.	Mean daily temperature.
	Oct. 2 to Nov. 4.							
Sept. 7							6	58
8							0	62
9							3	62
10							1	52
11							1	52
12							0	58
13							7	65
14							6	65
15							10	66
16							8	64
17							9	64
18							7	64
19							14	67
20							29	69
21							26	60
22							37	59
23							20	57
24							78	59
25							72	59
26							48	64
27							119	66
28							123	58
29							88	60
30							80	52
Oct. 1							42	48
2							50	52
3							134	58
4							93	54
5							99	50
6							0	44
7							82	50
8							61	45
9							16	43
10	1						15	45
11							26	45
12	1	1					36	40
13							2	38
15	1	4	1	2	1		177	55
16	1						144	50
17		1		2			55	49
18							121	64
19		3	1	1	1	1	124	47
20	2					4	100	40
21						1	6	43
22	1						7	41
23							8	40
24						1	6	42
25							6	42
26							2	44
27							0	42
28						3	32	44
29							10	48
30	3		1	1	4	7	46	31
31				1			1	32
Nov. 5						3	3	46
10							13	50
Jar discontinued	Nov. 21	Nov. 21	Nov. 21	Nov. 21	Nov. 21	Nov. 21	2,309	

PERCENTAGE OF COCOONING PREVIOUS TO AND DURING GRAPE HARVEST.

Table XXVI shows the time of cocooning of the larvæ that left the fruit in the fall of 1917. This does not necessarily indicate, however, that all the larvæ left the fruit before the end of grape harvest, for observation showed that a considerable part of the second brood of larvæ were only partially grown at the time of harvest and that large numbers of larvæ actually left the vineyards in the fruit. No accurate method of determining what part of the total number of larvæ were thus removed occurred to the writer, but an estimate of one-third would be conservative. This had a decided influence on the number of overwintering pupæ and subsequent infestation in 1918.

TABLE XXVI.—*Percentage of cocooning previous to and during grape harvest, Sandusky, Ohio, 1917.*

Time.	Date.	Number of cocoons.	Percentage of total.
Previous to beginning of Concord harvest	To Oct. 8	1,291	55.91
During Concord harvest	Oct. 8–18	653	28.28
Previous to end of Concord harvest	To Oct. 18	1,944	84.19
Previous to beginning of Catawba harvest	To Oct. 22	2,174	94.16
Previous to end of Catawba harvest	To Nov. 10	2,309	100.00

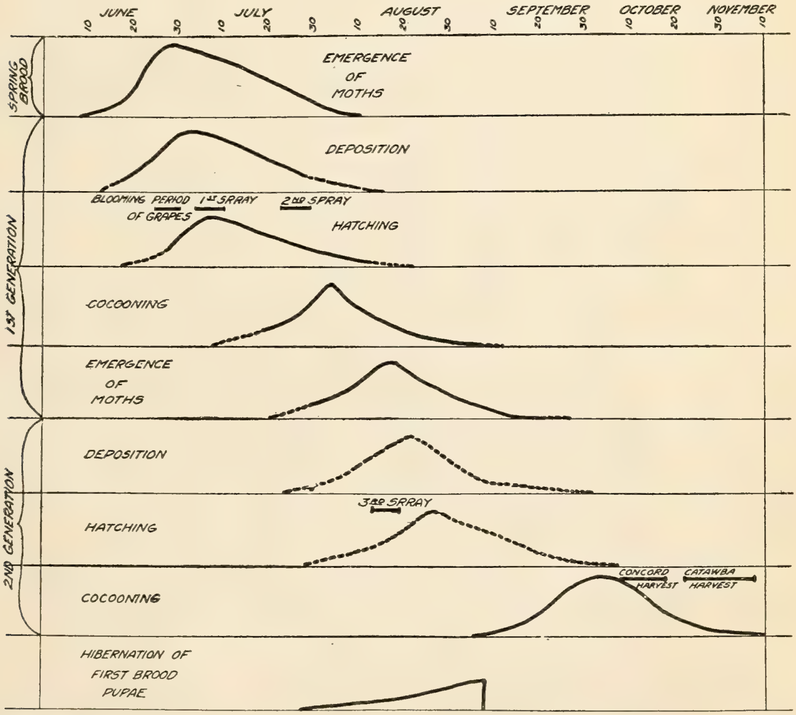

FIG. 3.—Diagram showing summary of the life-history data for 1917 of the grape-berry moth. Solid lines indicate actual records and dotted lines indicate occurrence of stages as observed in the field and computed from the average length of period.

SUMMARY OF SEASONAL-HISTORY STUDIES IN 1917.

A summary of the data presented in the preceding tables is shown graphically in figure 3.

It should be kept in mind in applying this diagram to future seasons that the season of 1917 was later than the average for northern Ohio and was unseasonably wet and cold throughout the fall.

SEASONAL-HISTORY STUDIES, 1918.

SPRING BROOD.

TIME OF EMERGENCE AND SEX OF MOTHS OF THE SPRING BROOD.

Table XXVII shows the dates of emergence of spring-brood moths and the number of each sex that emerged each day.

TABLE XXVII.—*Time of emergence and sex of moths of the spring brood of the grape-berry moth, Sandusky, Ohio, 1918.*

Date of emergence.	Number of moths.				Mean daily temperature.	Date of emergence.	Number of moths.				Mean daily temperature.
	♂	♀	⚥	Total.			♂	♀	⚥	Total.	
May 22	1	....	....	1	74	June 17	8	26	....	34	70
25	1	3	....	4	72	18	3	16	....	19	65
26	0	2	2	4	78	19	2	6	1	9	66
27	0	4	1	5	78	20	1	6	....	7	61
28	1	2	....	3	66	21	2	14	....	16	70
29	4	9	....	13	64	23	....	12	....	12	62
30	3	11	2	16	72	24	1	13	1	15	66
31	2	6	2	10	78	25	4	10	....	14	66
June 1	12	21	3	36	81	26	....	11	1	12	66
2	12	17	7	36	75	27	1	7	1	9	76
3	14	26	2	42	68	28	2	8	2	12	74
4	6	17	2	25	74	29	3	13	....	16	74
5	9	20	....	29	67	30	....	8	....	8	75
6	12	22	2	36	73	July 1	....	4	....	4	62
7	4	17	....	21	66	2	....	1	....	1	62
8	5	6	....	11	64	3	....	2	1	3	72
9	10	25	1	36	69	4	1	2	2	5	73
10	10	20	....	30	66	5	....	2	....	2	76
11	5	6	1	12	70	6	....	2	1	3	72
12	7	30	1	38	72	7	....	4	....	4	63
13	2	12	....	14	62	9	....	1	....	1	64
14	6	22	1	29	66	12	....	1	....	1	66
15	3	8	....	11	64						
16	4	7	1	12	72	Total...	161	482	38	681	

The early opening of the season hastened the grape growth and moth emergence was correspondingly early. The first emergence took place on May 22 and emergence in considerable numbers began on June 1. A rather high rate of emergence prevailed for about a two-week period and then gradually subsided. (Fig. 4.)

PROPORTION OF SEXES OF MOTHS OF THE SPRING BROOD.

TABLE XXVIII.—*Proportion of sexes of moths of spring brood of the grape-berry moth, Sandusky, Ohio, 1918.*

Sex of moths.	Number of moths.	Percentage of sexes.
Male	161	25.04
Female	482	74.96
Undetermined	38	....
Total	681	100.00

The proportions as shown in Table XXVIII are comparable with the figures in Table XI on the spring brood of moths in 1917. It appears that the preponderance of females is the usual condition.

PERCENTAGE OF EMERGENCE OF SPRING MOTHS.

The overwintering material was collected and kept under the same conditions as that of the previous winter. The percentage of emergence was slightly higher but still indicating a high rate of mortality.

TABLE XXIX.—*Percentage of emergence of spring moths of the grape-berry moth, Sandusky, Ohio, 1918.*

Source of material.	Number of cocoons.	Number of moths emerged.	Emergence.
Collected as larvæ at Venice, Kelleys Island, Put in Bay, and Dover, Ohio.	2,544	681	*Per cent.* 26.70

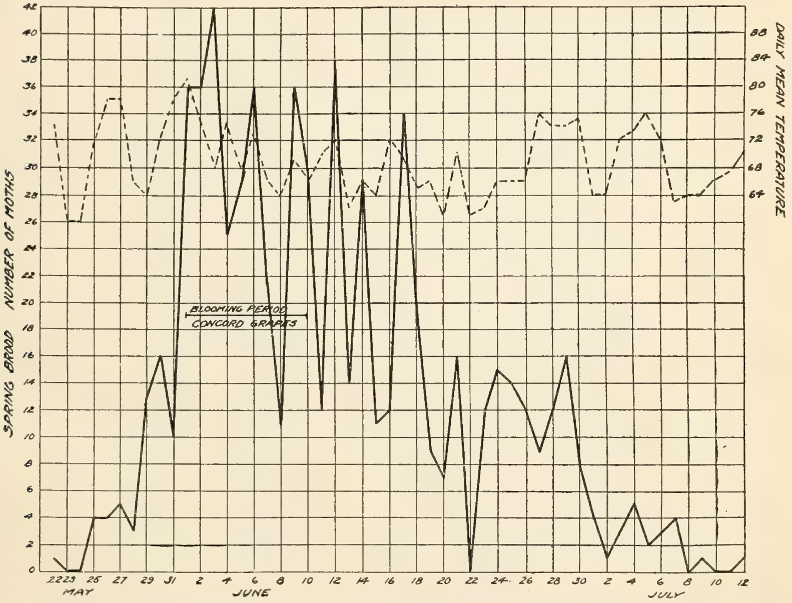

FIG. 4.—Diagram showing emergence of spring brood of moths of the grape-berry moth at Sandusky, Ohio, 1918.

The winter of 1917–18 was the most severe of 47 years on record at the Sandusky station of the United States Weather Bureau, and included intensely cold periods with little covering. This is of importance in connection with the foregoing records, for it must be concluded that the grape-berry moth pupæ are very resistant to severe winter conditions.

FIRST GENERATION.

TIME OF COCOONING AND LENGTH OF TIME IN THE COCOON OF FIRST-BROOD INDIVIDUALS.

TABLE XXX.—*Time of cocooning and length of time in cocoon of the first brood of the grape-berry moth, Sandusky, Ohio, 1918.*

Number of larvæ.	Date larvæ left fruit.	Moths emerged.	Days.		Number of larvæ.	Date larvæ left fruit.	Moths emerged.	Days.	
			In cocoon.	Total.				In cocoon.	Total.
1	July 7	July 23	16	16	5	Aug. 2	Aug. 13	11	55
4	July 9	...do....	14	56	9	...do.....	Aug. 14	12	108
1	...do.....	July 24	15	15	1	...do.....	Aug. 15	13	13
3	July 10	...do.....	14	42	6	Aug. 3	Aug. 14	11	66
3	July 11	...do.....	13	39	1	...do.....	Aug. 16	13	13
2	July 12	...do.....	12	24	12	Aug. 4	Aug. 15	11	132
3	...do.....	July 25	13	39	1	...do.....	Aug. 16	12	12
2	July 13	July 24	11	22	1	...do.....	Aug. 17	13	13
1	...do.....	July 25	12	12	1	...do.....	Aug. 18	14	14
2	...do.....	July 26	13	26	1	...do.....	Aug. 20	16	16
1	...do.....	July 27	14	14	1	Aug. 5	Aug. 17	12	12
3	July 14	July 26	12	36	3	Aug. 6	Aug. 18	12	36
2	...do.....	July 27	13	26	10	...do.....	Aug. 19	13	130
5	July 15	...do.....	12	60	5	...do.....	Aug. 20	14	70
1	...do.....	July 28	13	13	1	...do.....	Aug. 21	15	15
1	...do.....	July 29	14	14	3	Aug. 7	Aug. 18	11	33
2	July 16	July 27	11	22	9	...do.....	Aug. 19	12	108
3	...do....	July 28	12	36	12	...do.....	Aug. 20	13	156
2	...do.....	July 29	13	26	3	...do.....	Aug. 21	14	42
1	...do....	Aug. 2	17	17	2	...do.....	Aug. 22	15	30
9	July 17	July 29	12	108	2	...do.....	Aug. 23	16	32
2	...do.....	July 31	14	28	1	...do.....	Aug. 26	19	19
7	July 18	July 29	11	77	15	Aug. 8	Aug. 20	12	180
5	...do.....	July 30	12	60	18	...do.....	Aug. 21	13	234
11	...do.....	July 31	13	143	11	...do.....	Aug. 22	14	154
1	July 19	July 29	10	10	1	...do.....	Aug. 23	15	15
8	...do.....	July 31	12	96	5	Aug. 9	Aug. 21	12	60
3	...do.....	Aug. 1	13	39	22	...do.....	Aug. 22	13	286
1	...do.....	Aug. 2	14	14	12	...do.....	Aug. 23	14	168
1	July 20	July 30	10	10	1	...do.....	Aug. 25	16	16
3	...do.....	July 31	11	33	2	Aug. 10	Aug. 21	11	22
9	...do.....	Aug. 1	12	108	4	...do.....	Aug. 22	12	48
4	...do.....	Aug. 2	13	52	10	...do.....	Aug. 23	13	130
3	July 21	...do.....	12	36	1	...do.....	Aug. 24	14	14
9	...do.....	Aug. 3	13	117	1	...do.....	Aug. 25	15	15
7	...do.....	Aug. 4	14	98	3	Aug. 11	Aug. 23	12	36
16	July 22	...do.....	13	208	4	...do.....	Aug. 24	13	52
14	...do.....	Aug. 5	14	196	8	Aug. 12	...do....	12	96
1	...do.....	Aug. 6	15	15	9	...do.....	Aug. 25	13	117
18	July 23	Aug. 5	13	234	1	...do.....	Aug. 27	15	15
11	...do.....	Aug. 6	14	154	3	Aug. 13	Aug. 26	13	39
6	July 24	...do.....	13	78	2	...do.....	Aug. 27	14	28
1	July 25	Aug. 7	13	13	3	...do.....	Aug. 28	15	45
8	...do.....	Aug. 8	14	112	2	Aug. 14	Aug. 27	13	26
1	July 26	Aug. 6	11	11	2	...do.....	Aug. 28	14	28
8	...do.....	Aug. 8	13	104	4	Aug. 15	...do.....	13	52
10	...do.....	Aug. 9	14	140	2	...do.....	Aug. 29	14	28
2	July 27	Aug. 8	12	24	1	Aug. 16	Aug. 28	12	12
7	...do.....	Aug. 9	13	91	1	...do.....	Aug. 29	13	13
3	...do.....	Aug. 10	14	42	1	Aug. 17	Aug. 28	11	11
9	July 28	...do.....	13	117	2	...do.....	Aug. 29	12	24
6	...do.....	Aug. 11	14	84	2	...do.....	Aug. 30	13	26
1	July 29	Aug. 10	12	12	1	...do.....	Aug. 31	14	14
6	...do.....	Aug. 11	13	78	1	Aug. 18	...do.....	13	13
1	July 30	Aug. 10	11	11	1	Aug. 19	Sept. 2	14	14
1	...do.....	Aug. 11	12	12	1	Aug. 20	Sept. 4	15	15
7	July 31	Aug. 12	12	84	1	Aug. 21	Sept. 5	15	15
3	...do.....	Aug. 13	13	39	1	Aug. 22	Sept. 6	15	15
1	...do.....	Aug. 14	14	14	1	Aug. 23	...do....	14	14
2	Aug. 1	Aug. 12	11	22					
2	...do.....	Aug. 13	12	24	Total, 522	....	....	....	6,731
1	...do.....	Aug. 14	13	13					

Average days, 12.9.
Maximum days, 19.
Minimum days, 10.

It is seen in Table XXX that first-brood larvæ began to leave the fruit July 7 and continued to leave until August 23. The table does not show as well defined a high period as usually exists; the comparative dearth of rearing material is thought to account for this condition.

TIME OF EMERGENCE AND SEX OF FIRST-BROOD MOTHS.

The dates of emergence and number of moths are shown in Table XXXI and in graph in figure 5. Attention is directed to the rise in emergence on August 4 and 5 and then the sudden drop without another high point until August 20. The writer accounts for this, partly by a comparable drop in the cocooning in the period previous and partly by an actual killing of the pupæ by excessive heat that prevailed on August 5 to 8. On August 5 the official Weather Bureau records showed a maximum temperature of 94° F., on the 6th 105°, on the 7th 100°, and on the 8th 97°. When emergence dropped off suddenly on August 6 and 7 examination of the pupæ then about to transform to moths showed considerable mortality. Extensive records could not be taken without destroying the material that was to serve for further life-history studies.

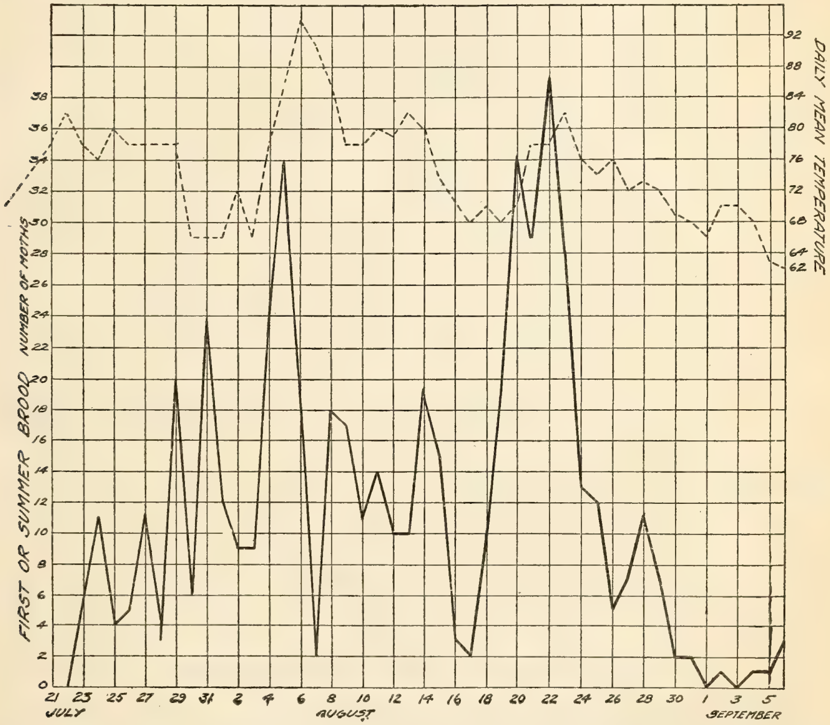

FIG. 5.—Diagram showing dates of emergence and number of moths of the grape-berry moth at Sandusky, Ohio, 1918.

TABLE XXXI.—*Time of emergence and sex of first-brood moths of the grape-berry moth, Sandusky, Ohio, 1918.*

Date of emergence.	Number of moths.				Mean daily temperature.	Date of emergence.	Number of moths.				Mean daily temperature.
	♂	♀	⚥	Total.			♂	♀	⚥	Total.	
					°*F.*						°*F.*
July 23	....	6	....	6	78	Aug. 15	1	14	....	15	74
24	1	9	1	11	76	16	....	3	....	3	71
25	1	3	....	4	80	17	1	1	....	2	68
26	....	5	0	5	78	18	....	9	....	9	70
27	1	9	1	11	78	19	2	17	....	19	68
28	....	2	1	3	78	20	7	25	2	34	70
29	2	15	3	20	78	21	6	20	3	29	78
30	1	3	2	6	66	22	14	23	2	39	78
31	6	16	2	24	66	23	9	17	2	28	82
Aug. 1	....	9	3	12	66	24	3	9	1	13	76
2	2	7	....	9	72	25	2	9	1	12	74
3	2	7	....	9	66	26	1	4	....	5	76
4	5	18	....	23	78	27	1	6	....	7	72
5	4	26	4	34	85	28	1	10	....	11	73
6	4	15	....	19	94	29	2	5	....	7	72
7	1	1	....	2	91	30	....	2	....	2	69
8	8	10	....	18	86	31	....	2	....	2	68
9	6	9	2	17	78	Sept. 2	1	....	....	1	70
10	4	5	2	11	78	4	....	1	....	1	68
11	2	12	....	14	80	5	....	1	....	1	63
12	....	9	1	10	79	6	1	2	....	3	62
13	2	8	....	10	82						
14	2	15	2	19	80	Total..	106	399	35	540	

PROPORTION OF SEXES OF FIRST-BROOD MOTHS.

TABLE XXXII.—*Proportion of sexes of first-brood moths of the grape-berry moth, Sandusky, Ohio, 1918.*

Sex of moth.	Number of moths.	Percentage of sexes.
Male	106	21.00
Female	399	79.00
Undetermined	35	....
Total	540	100.00

The proportion of sexes as shown in Table XXXII maintains the preponderance of females that has been shown in previous tables.

OVIPOSITION BY FIRST-BROOD MOTHS.

A single record of oviposition and incubation was secured. In a jar containing 14 male moths and 12 female moths, all of which emerged on August 22, 5 eggs were deposited on August 26 and hatched on September 2. The period from emergence to oviposition was therefore 4 days and the incubation period 7 days.

NUMBER OF TRANSFORMING AND OVERWINTERING INDIVIDUALS OF FIRST BROOD.

In Table XXXIII are presented the data on the overwintering first-brood individuals.

It will be seen that the first larva to hibernate left the fruit on August 2 and that the number gradually increased as the season progressed.

TABLE XXXIII.—*Number of transforming and overwintering individuals of the first brood of the grape-berry moth, Sandusky, Ohio, 1918.*

Number of larvæ.	Date larvæ left fruit.	Number of—			
		Moths emerged.	Pupæ hibernating.	Larvæ parasitized.	Dead.
1	June 30				1
1	July 7	1			
5	July 9	5			
4	July 10	3			1
4	July 11	3			1
5	July 12	5			
10	July 13	6		1	3
7	July 14	5		1	1
11	July 15	7		3	1
8	July 16	7		1	
23	July 17	11		3	9
25	July 18	23		1	1
18	July 19	13			5
26	July 20	17			9
29	July 21	19			10
44	July 22	31		1	12
41	July 23	29		1	11
34	July 24	6			28
21	July 25	9			12
22	July 26	19			3
19	July 27	13		1	5
20	July 28	15			5
12	July 29	7			5
4	July 30	2			2
14	July 31	11			3
11	Aug. 1	5			6
24	Aug. 2	15	1		8
9	Aug. 3	7			2
28	Aug. 4	16			12
37	Aug. 5	1	1		35
52	Aug. 6	19			33
55	Aug. 7	32	1		22
67	Aug. 8	45	2		20
48	Aug. 9	40	2		6
27	Aug. 10	18	1		8
12	Aug. 11	7	1		4
29	Aug. 12	18	3		8
13	Aug. 13	8	1		4
11	Aug. 14	4	4		3
8	Aug. 15	6	1		1
3	Aug. 16	2			1
6	Aug. 17	6			
5	Aug. 18	2	3		
1	Aug. 19	1			
3	Aug. 20	1	2		
5	Aug. 21	1	3		1
7	Aug. 22	1	5		1
10	Aug. 23	1	7		2
6	Aug. 24		6		
9	Aug. 25		9		
Total, 894		523	53	13	305

TABLE XXXIV.—*Summary of Table XXXIII, showing number and percentage of first brood individuals of the grape-berry moth that transform.*

Observations on—	Number.	Per cent.
Number of larvæ	894	100.0
Number of moths emerged	523	58.5
Number of hibernating pupæ	53	5.9
Number of parasitized larvæ	13	1.4
Number of dead individuals	305	34.1

Table XXXIV summarizes the data in Table XXXIII and shows that but 5.9 per cent of all the recorded larvæ hibernated, that 58.5 per cent emerged as moths the same season, that 1.4 per cent of the larvæ were parasitized when collected, and that 34.1 per cent of all died.

SECOND BROOD.

TIME OF COCOONING OF SECOND-BROOD LARVÆ.

Table XXXV presents the cocooning data in detail.

TABLE XXXV.—*Time of cocooning and number of cocoons of the grape-berry moth, Sandusky, Ohio, 1918.*

Date of cocooning.	Dates of collections of larvæ.					
	August—			September—		
	14	19	24	6	14	21
Aug. 15	2					
16	3					
17	2					
18	3					
19						
20	1	2				
21	1	3				
22		6				
23	3	7				
24	1	5				
25	7	2				
26	5	8	5			
27	3	3	1			
28	5	8	2			
29	2	8				
30	2	2	6			
31	1	4	1			
Sept. 1	1	1	2			
2	2	2	3			
3	1	3	4			
4	4	8	9			
5	1	2	2			
6		4	3			
7		5	2	1		
8		10	9	3		
9	1	3	7	9		
10	1	8	2	7		
11		6		2		
12	1	3	6	6		
13		1	2	3		
14	1	3	7	4		
15		6	10	10	2	
16		5	3	4	4	
17		1	2	8	1	
18		1	1		1	
19		1		3	1	
20			1	1		
21				1		
22		1	2	1		1
23		1	9	6	2	1
24			2	8	2	3
25		2	11	9	4	6
26				2	2	1
27			2	7	2	
28			2	6	3	5
29			4	5	3	4
30		1	1	3	2	1
Oct. 1				3	1	1
2			2	5	3	2
3			1	4	5	3
4				2	2	1
5			1	5	1	1
6			2	2	2	4
7					1	1
8				1		
9				2		
10			1			2
11						
12						2
13					1	
14						
15						
16						2
17						
18						
19						
20						
21						
22				1		
23				1		
24						
25						
26						
27						
28						
29				1		
30						
31						
Dates jars discontinued	Oct. 1	Oct. 21	Oct. 21	Nov. 1	Oct. 26	Nov. 1

Table XXXV.—*Time of cocooning and number of cocoons of the grape-berry moth, Sandusky, Ohio, 1918*—Continued.

Date of cocooning.	Dates of collections of larvæ.				Total cocoons.
	September—	October—			
	28	14	15	16	
Aug. 15					2
16					3
17					2
18					3
19					
20					3
21					4
22					6
23					10
24					6
25					9
26					18
27					7
28					15
29					10
30					10
31					6
Sept. 1					4
2					7
3					8
4					21
5					5
6					7
7					8
8					22
9					20
10					18
11					8
12					16
13					6
14					15
15					28
16					16
17					12
18					3
19					5
20					2
21					1
22					5
23					19
24					15
25					32
26					5
27					11
28					16
29	21				37
30	20				28
Oct. 1	9				14
2	17				29
3	11				24
4	7				12
5	34				42
6	20				30
7	3				5
8	3				4
9	9				11
10	6				9
11	4				4
12	1				3
13	3				4
14	3				3
15					0
16	2				4
17		2	4	3	9
18	10	6	7	3	26
19		3	2	2	7
20	2	2	5	5	14
21	1	4	6	4	15
22			1		2
23		2	1		4
24	3	8	6	1	18
25	1	4	4	5	14
26		1	1		2
27		1	5	2	8
28		2	1	3	6
29		2			3
30		1			1
31	1				1
Dates jars discontinued	Nov. 1	Nov. 1	Nov. 1	Nov. 1	842

Cocooning began as early as August 15 and continued until October 31.

PERCENTAGE OF COCOONING PREVIOUS TO AND DURING GRAPE HARVEST.

TABLE XXXVI.—*Percentage of cocooning previous to and during grape harvest, Sandusky, Ohio, 1918.*

Time.	Date.	Number of cocoons.	Percentage of total.
Previous to beginning of Concord harvest	To Sept. 20	343	40.73
During Concord harvest	Sept. 20–Oct. 10	342	40.62
Previous to end of Concord harvest	To Oct. 10	685	81.35
Previous to beginning of Catawba harvest	To Oct. 8	670	79.57
Previous to end of Catawba harvest	To Oct. 26	821	97.50
After Catawba harvest	To Nov. 1	21	2.50

The data in Table XXXV are summarized in Table XXXVI and emphasize similar records for the seasons of 1916 and 1917. From these records of three seasons involving a large quantity of larvæ regularly collected it must be concluded that a very large part of the second-brood larvæ leave the fruit previous to and during the early part of grape harvest.

MISCELLANEOUS RECORDS.

In the course of the life-history studies some observations were made that have a bearing on the habits of the insect and the development of the different stages.

ADULT.

The pupæ formed in the fall of 1916, from which moths emerged in the spring of 1917, were kept through the spring emergence period of 1918 to determine if any pupæ lived over and emerged the second spring. No moths emerged from this material the second year.

In an effort to approach natural conditions for moths in confinement dilute strained honey was supplied in the rearing jars. The usual observation was that the moths were not attracted to the food, but would feed if they came in contact with it. In one case when no new food had been supplied for six days, upon placing water on the sand in the bottom of the cage two moths immediately went 1½ inches to the water and appeared to drink of it.

The adults seldom are seen in the vineyards during the day, and throughout these investigations, though the writer was in heavily infested vineyards almost daily, moths were rarely observed. In one case a moth was seen resting on a young cluster of grape buds, another was observed on the upper side of a grape leaf, and a third adult was seen in flight about the lower part of a grapevine. It alighted on a cane, ran into the angle of a small stub on the cane, and rested there, its head in the angle.

MATING.

Mating was observed but once, this in the insectary on July 19, 1917, at 2.45 p. m. The moths emerged the day previous and the jar contained 4 males and 10 females with a sprig from a grapevine bearing a grape leaf and cluster. The moths were on the bottom of the jar, not mounted, but with their bodies in opposite directions, the posterior parts touching.

OVIPOSITION.

The following observations on oviposition were made in a heavily infested part of a large vineyard on June 30, 1917. Oviposition began about sundown or 6.30 p. m. When the moths first appeared they fluttered nervously about the vines, alighting seemingly at random, generally upon clusters, though often upon stems or leaves. Upon finding a cluster a moth would walk rapidly about upon a grape berry, covering practically the entire surface. Finally becoming quiet she would flex the abdomen until its tip touched the berry. During the process the abdomen twitched or shook slightly but the tip was at no time lifted and then replaced. The deposition of the egg required less than a minute's time but was not instantaneous. Upon completion of the deposition of a single egg the moth usually flew nervously away from the cluster. The following exception occurred among four depositions observed. A moth alighted upon a grape and oviposited immediately without any preliminary inspection and upon completion walked directly onto the next grape in the same cluster and repeated the operation.

The spring brood of moths deposits a considerable percentage of the eggs near the attachment of the grape to the cluster, and the first-brood moths seem frequently to select a place on the underside of the cluster, away from the light.

Repeated observation has shown that the moths discriminate between sprayed and unsprayed grapes as places for oviposition. This was most marked in one experimental vineyard in 1916. Four rows had been left unsprayed and the adjoining rows sprayed, with the exception of the side of one row next to the checks. This row was thoroughly sprayed from one side by the trailer method and the grape clusters well covered on that side. About a third of the surface of the clusters remained unsprayed and deposition by first-brood moths was apparently as heavy on this unsprayed surface as on the adjoining check rows, whereas practically no eggs were deposited on the sprayed side of the same clusters. This observation led to continued study on the same point and it was substantiated repeatedly during the investigations. That eggs are deposited to some extent on the sprayed surface has been shown by infestation of sprayed plats.

That early blooming varieties of grapes are more heavily infested than mid-season varieties has been known generally among grape growers. During these investigations the writer has been led to believe that the moths normally prefer to deposit their eggs on the formed grapes rather than on the unopened buds. This was strikingly shown in the case of the Clinton vine on which oviposition records were taken for Table XIV. On this single Clinton vine, growing in a row of the Concord variety with the Ives variety close by, were 994 grapes bearing eggs on June 29. Subsequently 630 more eggs were recorded on this one vine. Careful search was made on adjoining vines of the other varieties and not until the grapes were well formed could eggs be found, whereas heavy oviposition continued on the Clinton vine. Repeatedly vines of the Shrides variety, the earliest of any to bloom in northern Ohio, have been heavily infested with larvæ when adjoining vines of the Concord and Catawba varieties bore no eggs and were not infested. This condition also prevailed where several rows of the Clinton or other early blooming varieties paralleled rows of the later blooming varieties. In years of heavy infestation it is advisable to spray the early blooming varieties earlier than the midseason varieties.

EGG.

A single observation was made on the issuance of the larva from the egg, on August 9, 1916. When first observed, the head of the larva was just through the eggshell and 2½ minutes more were required for the larva to free itself entirely from the shell. The larva did not consume the empty eggshell.

LARVA.

Mention is often made of the habit of the first-brood larvæ to web the young grape clusters before or during bloom. In but one instance during three seasons has the writer seen these webbed clusters in the grapes of the mid-season blooming period. Webbing frequently occurs in the Delaware variety which is in full bloom a few days after the Concords and just at the time when the spring-brood moths are emerging in large numbers, as shown in figures 2 and 4. This same condition exists with the Norton variety, which blooms very late.

The grape-berry moth larvæ occasionally feed on grape leaves in the rearing cages even when grapes are present, and in at least one case a larva developed from about one-half size to maturity by feeding in this way.

LARVÆ FEEDING ON PHYLLOXERA GALLS.

On August 25, 1916, and again on October 2, 1917, vines of the Clinton variety of grape were observed which were heavily infested by the leaf form of the grape phylloxera. Examination of the phylloxera galls showed that they had been eaten into and in some cases much of the gall actually consumed. On these same leaves with the galls were thin white silken webs containing larvæ which closely resembled the grape-berry moth larvæ. A quantity of the leaves were collected on August 25, 1916, and placed in battery jars containing no other food for the larvæ. The larvæ at the time of collection varied from less than half-grown to nearly mature specimens. The leaves dried out but the larvæ completed their feeding and cocooned in the leaves, a total of 79 cocoons being secured. Pupæ from this material were identified by August Busck of the U. S. Bureau of Entomology as *Polychrosis viteana* Clem. The pupæ were kept over winter under outdoor conditions and 12 moths emerged the following spring. In a single instance an empty eggshell was found on the under surface of the leaves close to a phylloxera gall. In the observation made on October 2, 1917, about 1 leaf in 5 had the web formed by the larvæ which were feeding on the galls. In no case could it be definitely determined whether the phylloxera in the galls were consumed with the gall tissue. No leaf feeding other than on the galls occurred with the larvæ under observation.

CANNIBALISM AMONG GRAPE-BERRY MOTH LARVÆ.

To determine if the larvæ would be cannibalistic with a restricted food supply the following experiment was conducted: From field-collected second-brood larvæ, 40 between 4 and 7 mm. in length were taken and divided into two lots of 20 each on September 14, 1917. One lot was placed in a jar with 20 grapes and the other lot was similarly placed with but 5 grapes. Grape leaves were provided in both jars for pupation of the larvæ. On November 22 the following results were recorded: In the lot where 20 grapes were provided, 15 cocoons had been formed and 2 full-grown live larvæ were present. Considerable substance remained in the grapes. Careful search for the other 3 individuals failed to locate them. In the lot where but 5 grapes were supplied, 5 cocoons had been formed, 2 dead and 2 live larvæ were present, or a total of 9 accounted for. A careful search was made for the head shields of the other 11 larvæ but they were not to be found. All the pulp from all the grapes had been consumed. From this single experiment it appears that cannibalism exists among the larvæ when the food supply is restricted and may occur even with sufficient food present for all.

LARVÆ NOT KILLED BY LOW TEMPERATURES.

The resistance of grape-berry moth pupæ to severe winter conditions has been noted. On October 30, 1917, a severe freeze occurred in northern Ohio, sufficient to freeze Concord and Catawba grapes. The lowest temperature recorded at the Sandusky station of the United States Weather Bureau on October 30 was 25° F., 26° on October 31 and November 1, and 28° on November 2. When recording the results of spraying experiments at Put-in-Bay, Ohio, on November 5, and at Kelleys Island, Ohio, on November 7, live larvæ were plentiful in the grapes and no case was found where the larvæ had been killed by the freeze. In the insectary at Sandusky after a minimum temperature of 23° F. had been recorded, larvæ continued to leave the grapes and spin cocoons. Live larvæ persisted in the insectary on December 3, 1917, after a minimum temperature of 17° F. had been recorded.

LARVA SPINNING ITS COCOON.

On July 9, 1916, a first-brood larva was observed making its cocoon. When first observed the characteristic flap had been cut in the leaf but was not folded. The process observed was the turning over and tying down of the flap. The larva began at one end and by rapid movements of its head from the free edge of the flap to its place of attachment it gradually drew the flap over, the body of the larva resting on the flap, and eventually inclosed in it. The entire process observed occupied 35 minutes.

PARASITISM.

Considering the large numbers of individuals observed during these investigations the total amount of parasitism was very low, particularly among first-brood pupæ taken for the following emergence records.

That some parasitism of first-brood pupæ occurred is shown in Table XXXVII.

TABLE XXXVII.—*Percentage of parasitism of field collected first-brood grape-berry moth pupæ from Venice, Ohio, 1917.*

Date of collection.	Number of cocoons collected.	Number of parasites emerged.	Percentage of parasitism.
July 26	18	0	0
July 28	34	8	20.58
July 30	32	1	3.12
Aug. 1	41	11	26.82
Aug. 4	64	2	3.12
Aug. 6	47	8	17.02
Aug. 8	51	12	23.53
Aug. 10	35	12	34.28
Aug. 20	8	0	0
Do	31	4	12.90
Total	361	58	
Average			16.06

The parasitism of field-collected pupæ is seen to vary from 0 to 26 per cent with an average of 16 per cent for pupæ collected between July 26 and August 20.

In a single instance, September 8, 1916, eggs of the berry moth were found which were parasitized to an appreciable extent. A total of 760 eggs were collected on 11 clusters, of which 236, or 31 per cent, were parasitized. The parasite was not determined but was thought to be the same as recorded by Johnson and Hammar[1] at North East, Pa., in 1906, *Trichogramma pretiosa* Riley.

SUMMARY.

The present account of the life history of the grape-berry moth in northern Ohio is based upon a series of studies made in 1916, 1917, and 1918.

In the course of a year the grape-berry moth in northern Ohio produces one full brood and a partial second, the second brood of larvæ being much larger and more destructive than the first.

The grape-berry moth passes the winter in the pupal stage in cocoons in old grape leaves under the grape trellis. Under a leaf blanket approximating conditions in a protected part of a vineyard the mortality among the pupæ was 80 per cent during the winter of 1916–17 and 76 per cent during the winter of 1917–18.

The first moths emerge in the spring about 10 days before grapes begin to bloom but emerge in greatest numbers during and immediately following the period of grape bloom. In 1917 but 4 per cent emerged previous to bloom, 50 per cent during grape bloom, 25 per cent in the 10-day period following bloom, and the remaining 21 per cent later in the season. Moths begin ovipositing about 4 days after emergence and the eggs hatch in from 3 to 10 days, with 5 days as the average length of the egg stage.

The first-brood larvæ feed in the young grapes for a period of from 14 to 37 days, and the average length of the feeding period was 20.6 days in 1917. At the end of the feeding period the larvæ leave the grapes and go to tender grape leaves on the vines in which they spin their cocoons. The prepupal period lasted for from 1 to 3 days and averaged 1.77 days with the first brood in 1917, and lasted for from 3 to 7 days and averaged 4.15 days with the second brood in 1916. The pupal period varied from 11 to 16 days and averaged 13 days for first-brood pupæ in 1917. The total period in the cocoon varied from 6 to 32 days with an average period of 15 days.

The life cycle of the first generation in 1917, taken as a total of the average length of the separate stages, was 39.79 days. The total of the maximums was 76 days and of the minimums 23 days.

The incubation period of second-brood eggs varied from 4 to 10 days with 5.1 days as the average period. The feeding period of second-brood larvæ was from 16 to 36 days and averaged 24.18 days in 1916. All other records have given this period as about 40 days which is probably nearer the average condition than the figures presented here.

---

[1] Johnson, Fred, and Hammar, A. G. The grape-berry moth. U. S. Dept. Agr., Bur. Ent. Bul. 116, pt. II, p. 39. 1912.

Second-brood larvæ begin to leave the fruit early in the fall, August 22, 1916, August 15, 1918, September 7, 1917, but leave in greatest numbers just previous to and during the early part of the harvest season. In 1916, 77 per cent of the larvæ left the fruit previous to the beginning of the Concord harvest and 90 per cent previous to the beginning of the Catawba harvest. In 1917 corresponding figures were 56 per cent and 94 per cent.

In each brood of moths the females occur in much larger number than the males, the proportions being 21 per cent males, 79 per cent females in the spring brood, 1917; 18 per cent males, 82 per cent females in the summer brood, 1917; 25 per cent males, 75 per cent females in the spring of 1918; and 21 per cent males and 79 per cent females in the summer brood of 1918. A small part of the first-brood larvæ do not transform to moths the same season but hibernate and emerge as moths the following spring. In 1918 this amounted to 5.9 per cent of the total number recorded. Of the same lot of larvæ but 1.4 per cent were parasitized.

Mating and egg deposition were observed during these investigations. The habit of the grape-berry moth larvæ of feeding on grape leaf galls formed by the grapevine phylloxera was noted. Extreme resistance of the larvæ to low temperature was also noted, live larvæ persisting after a minimum temperature of 17° F. had occurred. Parasitism was very low and of little consequence as a control during these investigations.

Control measures recommended are cultural methods which will leave the overwintering pupæ exposed to the elements as much as possible. Satisfactory control was effected by two spray applications by the "trailer" or hand method of spraying. The first application should be made 3 to 5 days after the young grapes set and the second when the grapes first touch in the clusters.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
10 CENTS PER COPY
▽